

```
$ cat welcome.c
#include <stdio.h>

int main(int argc, char *argv[])
{
    printf("Welcome to COS 217\n");
    printf("Introduction to Programming Systems\n\n");
    printf("%s %d\n", "Fall", 2021);
    return 0;
}
```

```
$ cat Makefile
CC=gcc217
welcome: welcome.o
```

```
$ make
gcc217 -c -o welcome.o welcome.c
gcc217 welcome.o -o welcome
```

```
$ ./welcome
```

Welcome to COS 217
Introduction to Programming Systems

Fall 2021

Agenda



Course overview

- **Introductions**
- Course goals
- Resources
- Grading
- Policies

A taste of C

- History of C
- Building and running C programs
- Characteristics of C
- Java vs C



Introductions

Lead Faculty

- Szymon Rusinkiewicz smr@cs.princeton.edu

Lead Preceptors

- Xiaoyan Li xiaoyan@cs.princeton.edu
- Christopher Moretti cmoretti@cs.princeton.edu

Faculty Preceptor

- Donna Gabai dgabai@cs.princeton.edu

Preceptors

- Cedrick Argueta argueta@princeton.edu
- Weicong Dong weicongd@princeton.edu
- Huihan Li huihanl@princeton.edu
- Maxine Perroni-Scharf mp4215@princeton.edu

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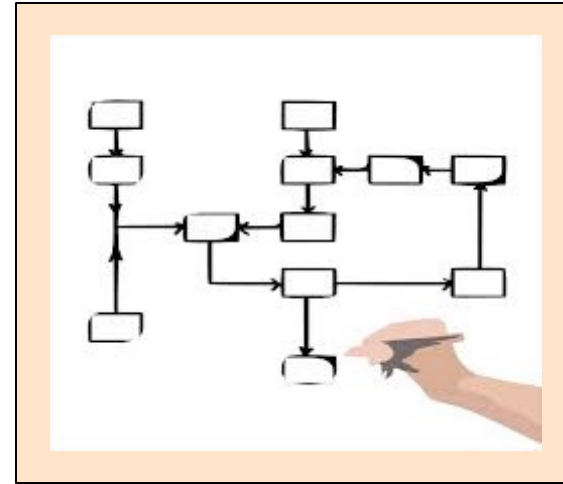
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Goal 1: Programming in the Large

Learn how to compose large(r) computer programs

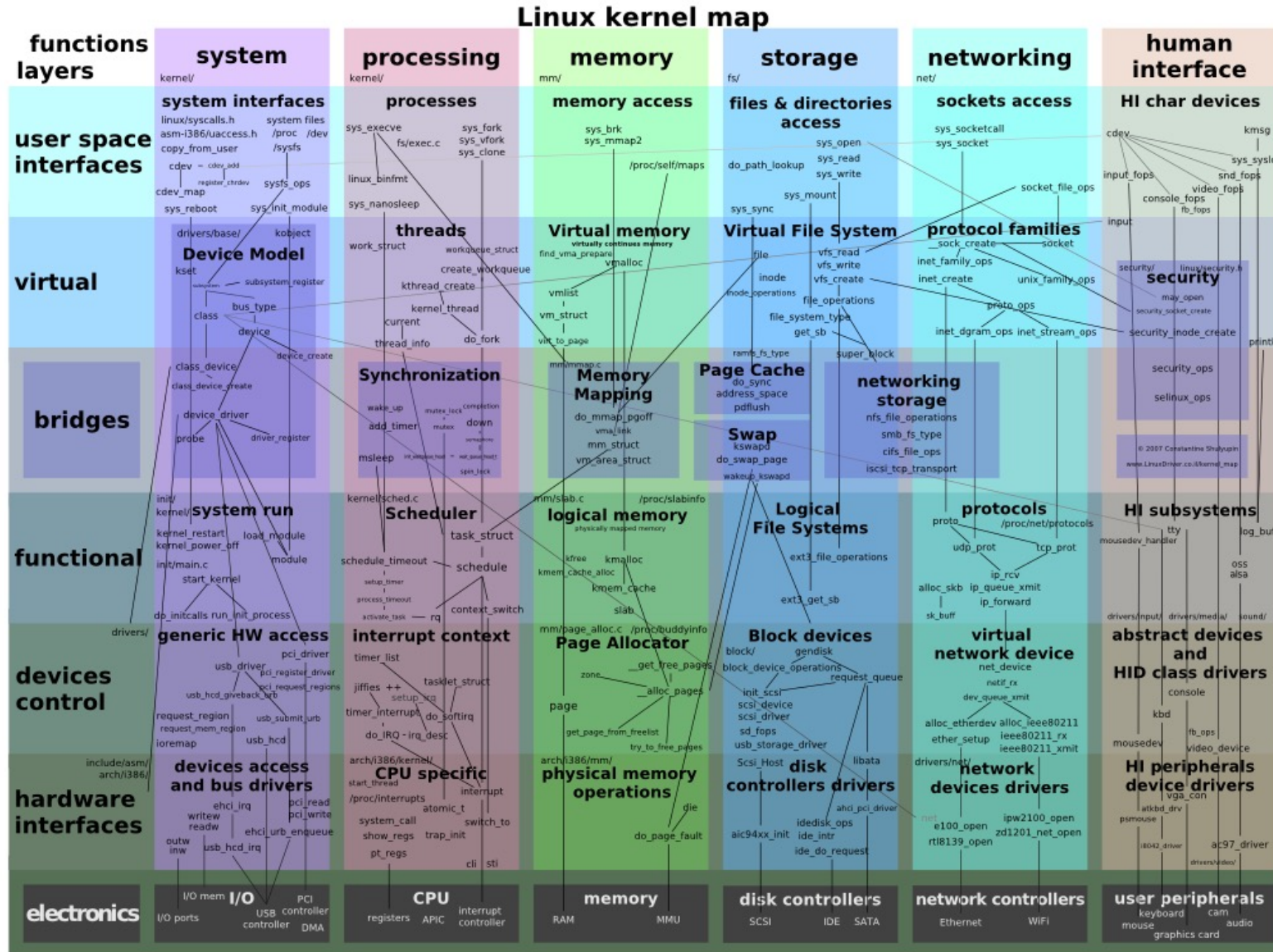


Topics

- Modularity/abstraction, information hiding, resource management, error handling, testing, debugging, performance improvement
- Tools: ssh, bash, shell utilities, emacs, git, gcc, make, gdb, gprof, valgrind



Modularity!





Goal 2: Lower-level Languages

```
int main(void) {
  while ((iChar = getchar()) != EOF) {
    lCharCount++;
    if (isspace(iChar)) {
      if (iInWord) {
        lWordCount++;
        iInWord = FALSE;
      }
    }
  }
}
```



```
main:
.LFB0:
.cfi_startproc
stp x29, x30, [sp, -16]!
.cfi_def_cfa_offset 16
.cfi_offset 29, -16
.cfi_offset 30, -8
add x29, sp, 0
.cfi_def_cfa_register 29
b .L2
```



```
RELOCATION RECORDS FOR [.eh_frame]:
OFFSET          TYPE          VALUE
000000000000001c R_AARCH64_PREL32 .text
```

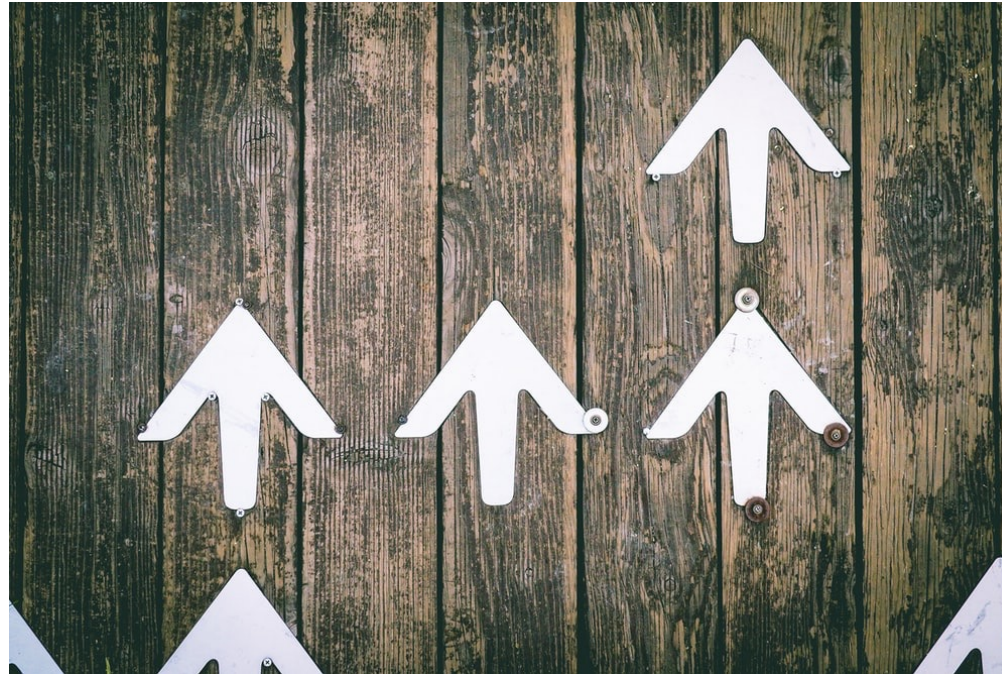
```
Contents of section .text:
 0000 fd7bbfa9 fd030091 39000014
00000090 .{.....9.....
```



Goals: Summary



Help you to gain ...



Jungwoo Hong

Programming Maturity



Specific Goal: Learn C

Question: Why C instead of Java?

Answer 1: A primary language for “under the hood” programming in real code bases.

Answer 2: A variety of experience helps you “program in the large”





Specific Goal: Learn Linux

Question: Why use the Linux operating system?

Answer 1: Linux is the industry standard for servers, embedded devices, education, and research

Answer 2: Linux (with GNU tools) is good for programming (which helps explain answer 1)

Linux™

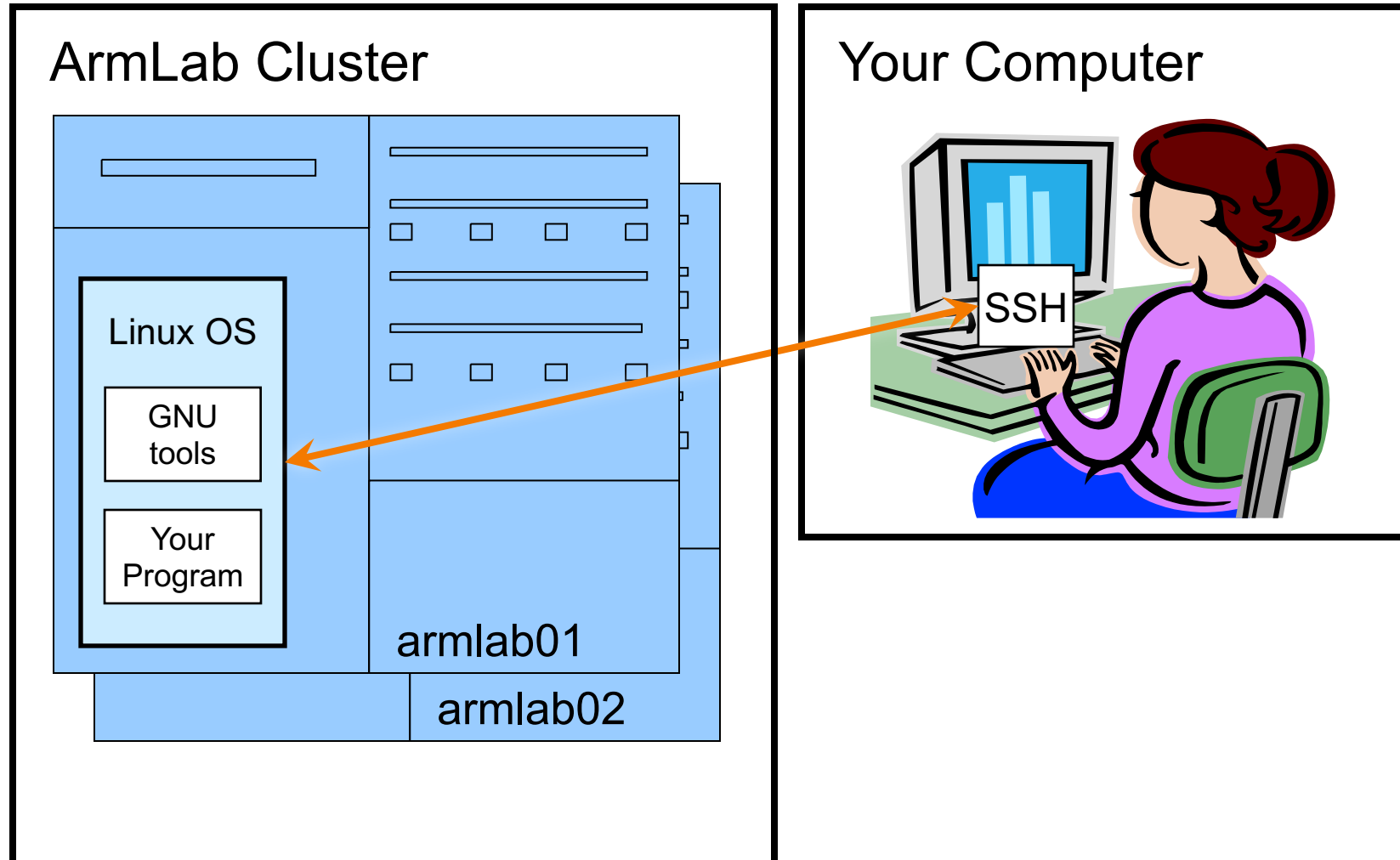


Programming Environment



Server

Client



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Lectures

Describe material at a mix of levels

- Some conceptual (high) overview
- Some digging into details

Slides on course website

Videos from last year available on Youtube



Etiquette

- Use electronic devices *only* for taking notes or annotating slides
(but consider taking notes by hand – research shows it works better!)
- No SnapFaceNewsBookInstaGoo, please

iClicker



Occasional questions in class, graded on participation
(with a generous allowance for not being able to attend)

- Can use either a physical remote, an app on your phone, or web
- Create account / register at [iclicker.com](https://www.iclicker.com)
 - If asked, we're using "iClicker Cloud" and "Canvas"

iClicker Question

Q: Do you have an iClicker (remote or app) with you today?

A. Yes

B. No, but I've been practicing my mental electrotelekinesis and the response is being registered anyway

C. I'm not here, but someone is iClicking for me
(don't do this – it's a violation of our course policies!)



Precepts

Describe material at the “practical” (low) level

- Support your work on assignments
- Hard-copy handouts distributed in precept
- Handouts available via course website

Etiquette

- Attend your precept: attendance will be taken
- Must miss your precept? ⇒ inform preceptors & attend another
- Use TigerHub to move to another precept

Precepts begin next Wednesday / Thursday (Sep 8 and 9)!

Websites



<https://www.cs.princeton.edu/~cos217> (Course website)

- Home page, schedule page, assignment page, policies page

<https://princeton.instructure.com/courses/4040> (Canvas)

- Links to Ed, Library reserves and other readings, NameCoach





<https://us.edstem.org/us/courses/8696/discussion/>

- Also available as a Canvas link
- Q&A – post here instead of emailing staff



Etiquette

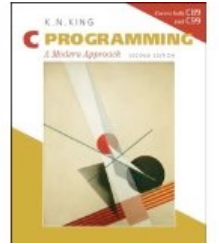
- Study provided material before posting question
 - Lecture slides, precept handouts, required readings
- Read / search all (recent) Ed threads before posting question
- Don't reveal your code!
 - See course policies
 - Click “private” if in doubt

Books



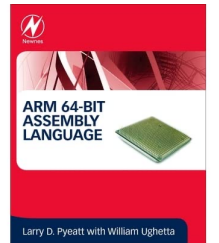
C Programming: A Modern Approach (Second Edition) (required)

- King
- C programming language and standard libraries



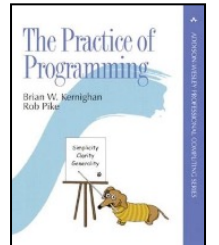
ARM 64-bit Assembly Language (online)

- Pyeatt with Ughetta



The Practice of Programming (online)

- Kernighan & Pike
- “Programming in the large”





Manuals

Manuals (for reference only, available online)

- *ARMv8 Instruction Set Overview*
- *ARM Architecture Reference Manual*
- *Using `as`, the GNU Assembler*

See also

- Linux *man* command



Help!



Office Hours

- Preceptors: 2+ hours scheduled every weekday + Sunday, in-person and Zoom
- Me: after lecture or sign up via <https://calendly.com/smr-princeton>
- Schedule is on the course website
- Zoom form / links are on Canvas

Lab TAs

- Your peers are available 4+ hours per day, every single day
- These are specific to debugging your assignments.
For conceptual help with course materials, go to office hours.
- <https://labta.cs.princeton.edu/>

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Grading



Course Component	Percentage of Grade
Assignments *	60
Midterm Exam **	10
Final Exam **	20
Participation ***	10

- * 6 assignments × 10% each. Late assignments 20% off per day; 4 late days free.
- ** During midterms week and final exam period, respectively. Closed book/notes.
- *** Did your involvement benefit the course?
 - Lecture/precept attendance and precept/Ed participation



Programming Assignments

Regular (every 1.5-2.5 weeks) assignments

0. Introductory survey
1. “De-comment” program
2. String module
3. Symbol table module
4. Debugging directory and file trees *
5. Assembly language programming *
6. Buffer overrun attack *

*(partnered assignment)



Assignments 0 and 1 are available now: **start early!!**

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Policies

Learning is a collaborative activity!

- Discussions with others that help you understand concepts from class are encouraged

But programming assignments are graded!

- Everything that gets submitted for a grade must be exclusively your own work
- Don't look at code from someone else, the web, Github, etc. – see the course “Policies” web page
- Don't reveal your code or design decisions to anyone except course staff – see the course “Policies” web page

Violations of course policies

- Typical course-level penalty is 0
- Typical University-level penalty is suspension



Sanity



COS 1xx/2xx courses are hard under the best of circumstances

- Information-dense
- Programming is a new skill, or “craft”: not like writing essays or doing problem sets

These are not the best of circumstances

- We are all worried about ourselves, friends, family
- We all feel stressed, anxious, uncertain – but when these veer into panic or depression...

Say something, and get help

- Reach out to CPS, your residential college dean, course staff
- No judgment – the rest of us are feeling it too

Questions?

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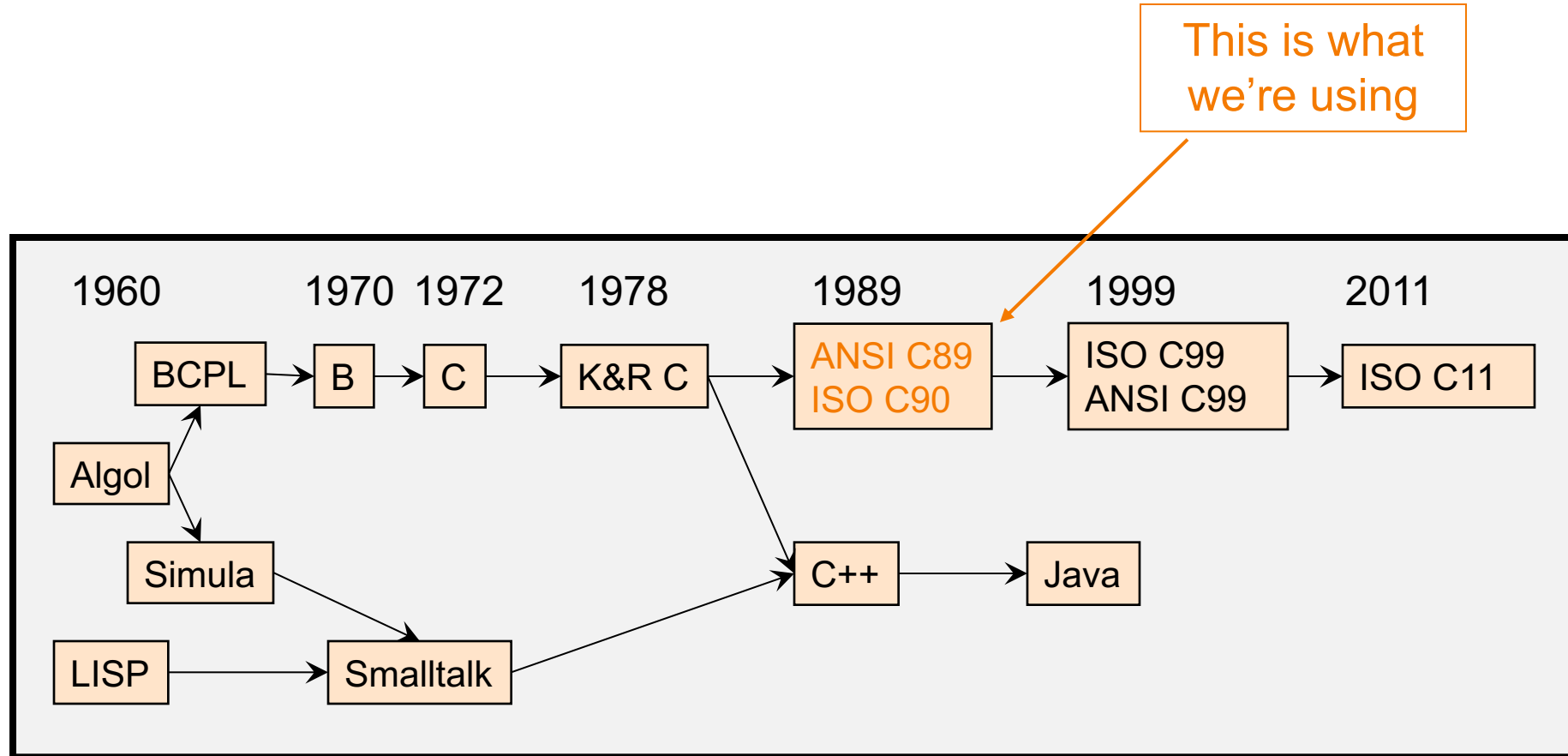
The C Programming Language



Who? Dennis Ritchie
When? ~1972
Where? Bell Labs
Why? Build the Unix OS



Java vs. C: History



C vs. Java: Design Goals



C Design Goals (1972)	Java Design Goals (1995)
Build the Unix OS	Language of the Internet
Low-level; close to HW and OS	High-level; insulated from hardware and OS
Good for system-level programming	Good for application-level programming
Support structured programming	Support object-oriented programming
Unsafe: don't get in the programmer's way	Safe: can't step "outside the sandbox"
	Look like C!

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A taste of C

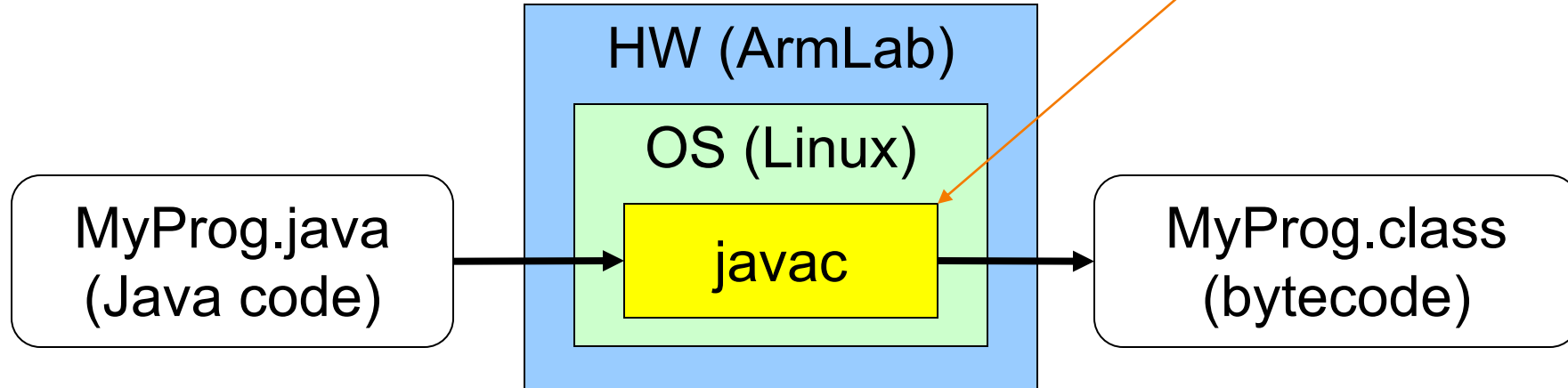
- History of C
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Building Java Programs

`$ javac MyProg.java`

Java compiler
(machine lang code)

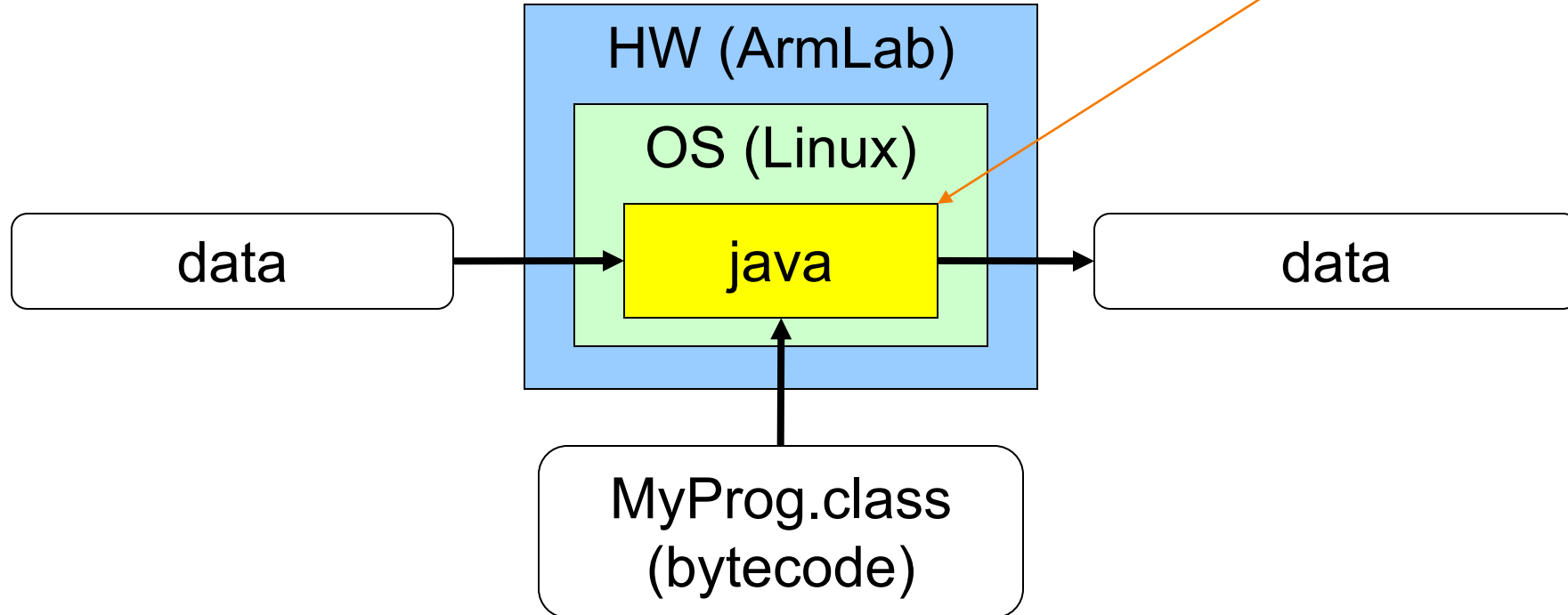




Running Java Programs

`$ java MyProg`

Java interpreter /
"virtual machine"
(machine lang code)

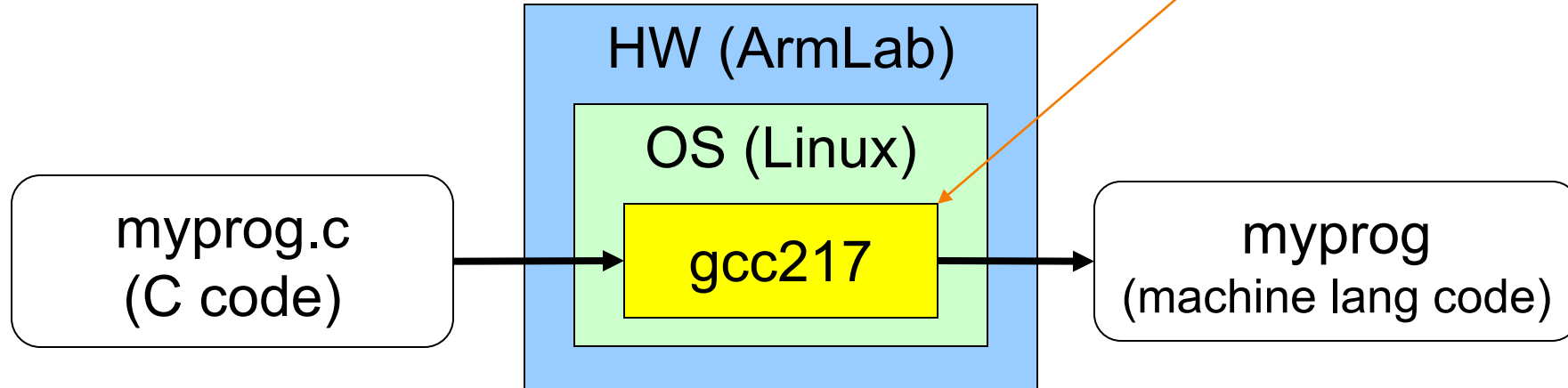




Building C Programs

```
$ gcc217 myprog.c -o myprog
```

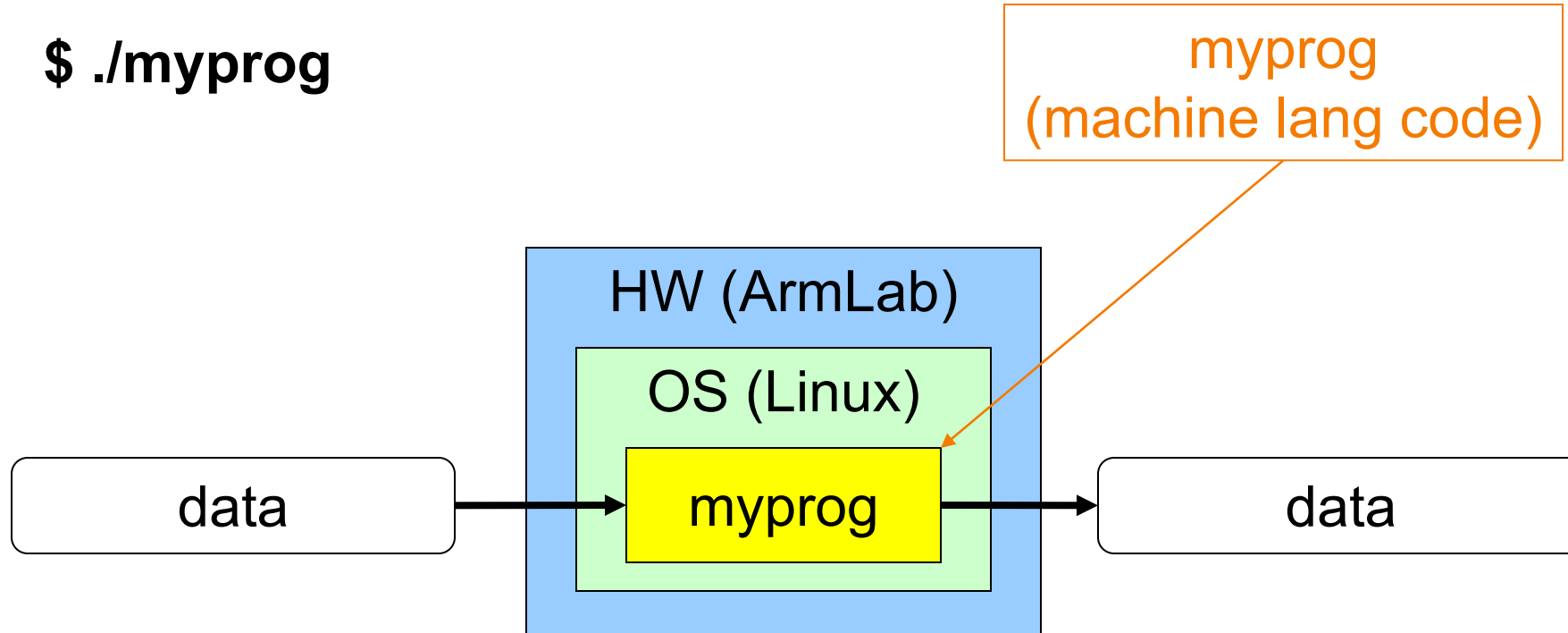
C “Compiler driver”
(machine lang code)



Running C Programs



`$./myprog`



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Java vs. C: Portability

Program	Code Type	Portable?
MyProg.java	Java source code	Yes
myprog.c	C source code	Mostly
MyProg.class	Bytecode	Yes
myprog	Machine lang code	No

Conclusion: Java programs are more portable

(For example, COS 217 has used many architectures over the years, and every time we switched, all our programs had to be recompiled!)



Java vs. C: Safety & Efficiency

Java

- Automatic array-bounds checking,
- NULL pointer checking,
- Automatic memory management (garbage collection)
- Other safety features

C

- Manual bounds checking
- NULL pointer checking,
- Manual memory management

Conclusion 1: Java is often safer than C

Conclusion 2: Java is often slower than C

▶ iClicker Question

Q: Which corresponds to the C programming language?

A.



B.



C.





Example C Program

```
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    const double KMETERS_PER_MILE = 1.609;
    int miles;
    double kMeters;

    printf("miles: ");
    if (scanf("%d", &miles) != 1)
    {
        fprintf(stderr, "Error: Expected a number.\n");
        exit(EXIT_FAILURE);
    }

    kMeters = (double)miles * KMETERS_PER_MILE;
    printf("%d miles is %f kilometers.\n",
           miles, kMeters);
    return 0;
}
```

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- **Java vs C**

Java vs. C: Details



Remaining slides provide some details

Use for future reference

Slides covered now, as time allows...

Java vs. C: Details



	Java	C
Overall Program Structure	<pre>Hello.java: public class Hello { public static void main (String[] args) { System.out.println("hello, world"); } }</pre>	<pre>hello.c: #include <stdio.h> int main(void) { printf("hello, world\n"); return 0; }</pre>
Building	<pre>\$ javac Hello.java</pre>	<pre>\$ gcc217 hello.c -o hello</pre>
Running	<pre>\$ java Hello hello, world \$</pre>	<pre>\$./hello hello, world \$</pre>

Java vs. C: Details



	Java	C
Character type	<code>char // 16-bit Unicode</code>	<code>char /* 8 bits */</code>
Integral types	<code>byte // 8 bits</code> <code>short // 16 bits</code> <code>int // 32 bits</code> <code>long // 64 bits</code>	<code>(unsigned, signed) char</code> <code>(unsigned, signed) short</code> <code>(unsigned, signed) int</code> <code>(unsigned, signed) long</code>
Floating point types	<code>float // 32 bits</code> <code>double // 64 bits</code>	<code>float</code> <code>double</code> <code>long double</code>
Logical type	<code>boolean</code>	<code>/* no equivalent */</code> <code>/* use 0 and non-0 */</code>
Generic pointer type	<code>Object</code>	<code>void*</code>
Constants	<code>final int MAX = 1000;</code>	<code>#define MAX 1000</code> <code>const int MAX = 1000;</code> <code>enum {MAX = 1000};</code>

Java vs. C: Details



	Java	C
Arrays	<pre>int [] a = new int [10]; float [][] b = new float [5][20];</pre>	<pre>int a[10]; float b[5][20];</pre>
Array bound checking	<pre>// run-time check</pre>	<pre>/* no run-time check */</pre>
Pointer type	<pre>// Object reference is an // implicit pointer</pre>	<pre>int *p;</pre>
Record type	<pre>class Mine { int x; float y; }</pre>	<pre>struct Mine { int x; float y; };</pre>



Java vs. C: Details

	Java	C
Strings	<code>String s1 = "Hello"; String s2 = new String("hello");</code>	<code>char *s1 = "Hello"; char s2[6]; strcpy(s2, "hello");</code>
String concatenation	<code>s1 + s2 s1 += s2</code>	<code>#include <string.h> strcat(s1, s2);</code>
Logical ops *	<code>&&, , !</code>	<code>&&, , !</code>
Relational ops *	<code>==, !=, <, >, <=, >=</code>	<code>==, !=, <, >, <=, >=</code>
Arithmetic ops *	<code>+, -, *, /, %, unary -</code>	<code>+, -, *, /, %, unary -</code>
Bitwise ops	<code><<, >>, >>>, &, ^, , ~</code>	<code><<, >>, &, ^, , ~</code>
Assignment ops	<code>=, +=, -=, *=, /=, %= <<=, >>=, >>>=, &=, ^=, =</code>	<code>=, +=, -=, *=, /=, %= <<=, >>=, &=, ^=, =</code>

* Essentially the same in the two languages

Java vs. C: Details



	Java	C
if stmt *	<pre>if (i < 0) statement1; else statement2;</pre>	<pre>if (i < 0) statement1; else statement2;</pre>
switch stmt *	<pre>switch (i) { case 1: ... break; case 2: ... break; default: ... }</pre>	<pre>switch (i) { case 1: ... break; case 2: ... break; default: ... }</pre>
goto stmt	// no equivalent	goto <i>someLabel</i> ;

* Essentially the same in the two languages

Java vs. C: Details



	Java	C
for stmt	<pre>for (int i=0; i<10; i++) <i>statement</i>;</pre>	<pre>int i; for (i=0; i<10; i++) <i>statement</i>;</pre>
while stmt *	<pre>while (i < 0) <i>statement</i>;</pre>	<pre>while (i < 0) <i>statement</i>;</pre>
do-while stmt *	<pre>do <i>statement</i>; while (i < 0)</pre>	<pre>do <i>statement</i>; while (i < 0);</pre>
continue stmt *	<pre>continue;</pre>	<pre>continue;</pre>
labeled continue stmt	<pre>continue <i>someLabel</i>;</pre>	<pre>/* no equivalent */</pre>
break stmt *	<pre>break;</pre>	<pre>break;</pre>
labeled break stmt	<pre>break <i>someLabel</i>;</pre>	<pre>/* no equivalent */</pre>

* Essentially the same in the two languages

Java vs. C: Details



	Java	C
return stmt *	<code>return 5;</code> <code>return;</code>	<code>return 5;</code> <code>return;</code>
Compound stmt (alias block) *	<code>{</code> <i>statement1</i> ; <i>statement2</i> ; <code>}</code>	<code>{</code> <i>statement1</i> ; <i>statement2</i> ; <code>}</code>
Exceptions	<code>throw, try-catch-finally</code>	<code>/* no equivalent */</code>
Comments	<code>/* comment */</code> <code>// another kind</code>	<code>/* comment */</code>
Method / function call	<code>f(x, y, z);</code> <code>someObject.f(x, y, z);</code> <code>SomeClass.f(x, y, z);</code>	<code>f(x, y, z);</code>

* Essentially the same in the two languages

Summary



Course overview

- Introductions
- Course goals
 - Goal 1: Learn “programming in the large”
 - Goal 2: Look “under the hood” and learn low-level programming
 - Use of C and Linux supports both goals
- Resources
 - Lectures, precepts, programming environment, Ed, textbooks
 - Course website: access via <https://www.cs.princeton.edu/~cos217>
- Grading
- Policies

Summary



Getting started with C

- History of C
- Building and running C programs
- Characteristics of C
- Details of C
 - Java and C are similar
 - Knowing Java gives you a head start at learning C



Getting Started

Check out course website **soon**

- Study “Policies” page

Next Tuesday: computing environment

- In preparation for assignments 0 and 1